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Four new *Lepraria* species for Iran, with a key to all Iranian species

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Abstract—*Lepraria eburnea*, *L. ecorticata*, *L. jackii*, and *L. leuckertiana*, found in deciduous forests in Golestan province, are recorded for the first time from Iran. Descriptions and illustrations of all four species and a key to all *Lepraria* species known from Iran are provided.

Key words—Hyrcanian forest, leprose lichens, sterile lichens

Introduction

Species of *Lepraria* Ach. (*Stereocaulaceae, Lecanoromycetes*) are characterized by thalli completely composed of more or less clusters of soredia resting on a continuous medulla (Lendemer 2013). They lack ascocarps or conidangia; therefore with few morphological features available as taxonomic characters, the presence of secondary metabolites plays a significant role in distinguishing species (Leuckert & al. 1995, Saag & al. 2009). DNA analyses by Ekman & Tønsberg (2002) confirmed the taxonomic status of the genus and its species. ITS analysis by Bayerová & al. (2005) showed that species may be distinguished through subtle differences in aliphatic acid content, difficult to trace using the usual TLC methods.

Lepraria is widely distributed with 61 species currently known worldwide (Sipman 2004, Saag & al. 2009, Matwiejuk 2017). In Asia it is known from Armenia, China, India, Mongolia, Pakistan, Singapore, Tajikistan, and Turkey. Eleven species have been reported from Iran: Sohrabi & Orange (2006) and Sohrabi & al. (2010) report *L. lobificans* Nyl. and *L. diffusa* (J.R. Laundon) Kukwa from Golestan and Mazandaran provinces, *L. vouauxii* (Hue) R.C. Harris from East Azerbaijan and Golestan provinces, *L. crassissima* (Hue) Lettau from Mazandaran, and *L. alpina* (B. de Lesd.) Tretiach & Baruffo and *L. nivalis* J.R. Laundon from Zanjan province; Valadbeigi & al. (2009) report *L. isidiata* (Llimona) Llimona & A. Crespo from Ilam; Haji Moniri & Kukwa (2009) report *L. caesioalba* (B. de Lesd.) J.R. Laundon and *L. rigidula* (B. de Lesd.) Tønsberg from Northern Khorasan; Kukwa & Sohrabi (2008) report *L. impossibilis* Sipman from Mazandaran province; and Dyanat-Nejad & Keramedini (1993) report *L. membranacea* (Dicks.) Vain. from Tehran province.

The Golestan province is particularly promising for lichens due to its extensive Hyrcanian forests dominated by *Parrotia persica* (DC.) C.A. Mey., *Quercus castaneifolia* C.A. Mey., *Acer velutinum* Boiss., *Gleditsia caspia* Desf., *Pyrus boissieriana* Buhse, and *Alnus subcordata* C.A. Mey. (Akhani & al. 2010). Only three *Lepraria* species have previously been identified from Golestan province (Sohrabi & Orange 2006): *L. lobificans*, *L. diffusa*, and *L. vouauxii*. We report new to Iran and describe four additional species from Naharkhoran Forest in Golestan found in wet and shady habitats, often on thick *Quercus* bark and on mosses over bark. We also provide a key to all *Lepraria* species known from Iran, including *L. finkii* (B. de Lesd.) R.C. Harris, which has been confused with *L. lobificans* (Lendemer 2013).

Material & methods

The specimens are deposited in the Herbarium, Research Institute of Forests and Rangelands, Tehran, Iran (TARI) and were compared with herbarium samples in the Herbarium, Botanischer Garten und Botanisches Museum Berlin-Dahlem, Berlin, Germany (B). Morphological and anatomical characters were observed with a Luxeo 4D stereomicroscope and a Zeiss compound microscope. The chemistry was analyzed with thin layer chromatography (TLC) following Orange & al. (2010) and Elix (2014) using solvent systems A (toluene, dioxane, acetic acid), B' (hexane, diethyl ether, formic acid), and C (toluene, acetic acid). For identification, the keys of Saag & al. (2009) and Knudsen & Elix (2007) were also used.

Taxonomy

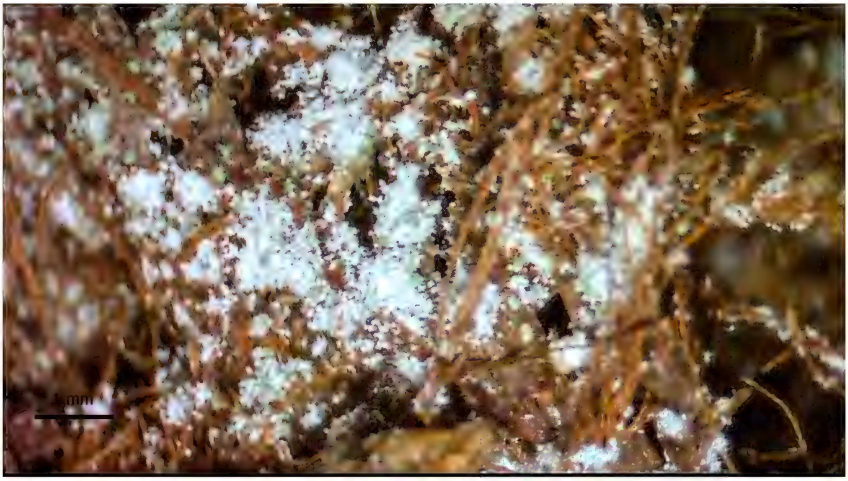

Fig. 1. *Lepraria eburnea* (TARI, Kazemi 9023).

Lepraria eburnea J.R. Laundon, Lichenologist 24: 332. 1992. Fig. 1

Type: British Isles, England, London Borough of Hammersmith and Fulham (V.C. 21, Middlesex), All Saints Fulham churchyard, 51/243759, in slight shade on moss, brick, and mortar on vertical surface of brick wall on east side of churchyard, 30.vi.1987, on calcareous rocks, J.R. Laundon 3185 (BM [n.v.], holotype).

Thallus white-grey to white-green, turning pale pink in the herbarium due to its alectorialic acid content, thick, leprose, placodioid, without wrinkled margin, diffuse, persistent and clearly two-layered, initially forming small patches of thallus that are later incorporated into the margin, without lobes; hyphae unilateral, hyaline, septate; initially with prothallus; hypothallus with variously developed layer of hyphae around and under the granules, thick and white, without rhizohyphae, granules spherical, fuzzy, and ecorticate, with short projecting hyphae, forming multiplex units (consoredia).

Chemistry: thallus K+ yellow, C+ yellow, KC+ pink.

TLC: Alectorialic acid, protocetraric acid.

Specimen examined: **IRAN**, **Golestan province**: **Gorgan**, Alangdareh Forest, around health road, 36.7928°N 54.4504°E, 341 m, 16.11.2017, Kazemi 9023 (TARI).

Comments: Our material agrees with the most detailed descriptions of *L. eburnea* presented by Saag & al. (2009), Kukwa (2006), and Tsurykau & al. (2016).

Lepraria eburnea is similar to *L. nivalis*, in that both species have protocetraric acid and grow on mosses; however, *L. nivalis* differs by its growth on mosses covering calcareous rocks, not bark and its absence of alectorialic acid.

Lepraria eburnea is morphologically similar to *L. finkii* in that both have a thick white medulla; they are separated by chemical differences: *L. finkii* has atranorin, stictic acid, and zeorin as secondary metabolites.

HABITAT: *Lepraria eburnea* grows on sheltered microhabitats in mountainous regions as well as on partially shaded moss, brick, and mortar on vertical brick wall surfaces and on acidic substrates, soil, *Alnus glutinosa*, and *Quercus robur* (Laundon 1992, Kukwa 2006, Lendemer 2013). The specimen reported here was found on mosses on large *Quercus castaneifolia* tree in Hyrcanian forest.

GEOGRAPHICAL DISTRIBUTION: Asia (Armenia, Turkey) (Gasparyan & Sipman 2016, Cobanoglu & Akdemir 2000), Europe, North America (Saag 2009).

Lepraria ecorticata (J.R. Laundon) Kukwa, Mycotaxon 97: 64. 2006 FIG. 2

TYPE: British Isles, England, Devon [vice-c 4], Ilfracombe, Torrs Walks, 21/50 47, on shaded vertical rocks, 1 September 1971, J.R. Laundon 2851 (BM [n.v.], holotype).

Thallus yellowish-green to bluish-grey, leprose; without margin, granules in to irregular mass, without lobes; medulla thin and pale, rarely differentiated, often absent; hyphae aggregate, without septa, pale, covered with granular crystals, soredia abundant, without projecting hyphae, ecorticate, mostly fine to medium, well separated from one another.

CHEMISTRY: K+ pale yellow, C–, KC–, Pd–.

TLC: Atranorin, usnic acid, zeorin.

SPECIMEN EXAMINED: **IRAN**, **GOLESTAN PROVINCE**: **Gorgan**, Naharkhoran road, Delbar mountain, 36.7223°N 54.5490°E, 1049 m, 17.11.2017, Kazemi 8784 (TARI).

COMMENTS: Our specimen agrees with the detailed descriptions of *L. ecorticata* presented by Kukwa (2006), Saag & al. (2009), Laundon (2003), Flakus & Kukwa. (2007).

In Iran *Lepraria ecorticata* is similar chemically with *L. leuckertiana*, as both have usnic acid and zeorin, but *L. ecorticata* is distinguished by having well-separated soredia and lacking a distinct medulla and marginal lobes, while *L. leuckertiana* has irregular and greatly coalescing soredia, a thick medulla, and minute marginal lobes.

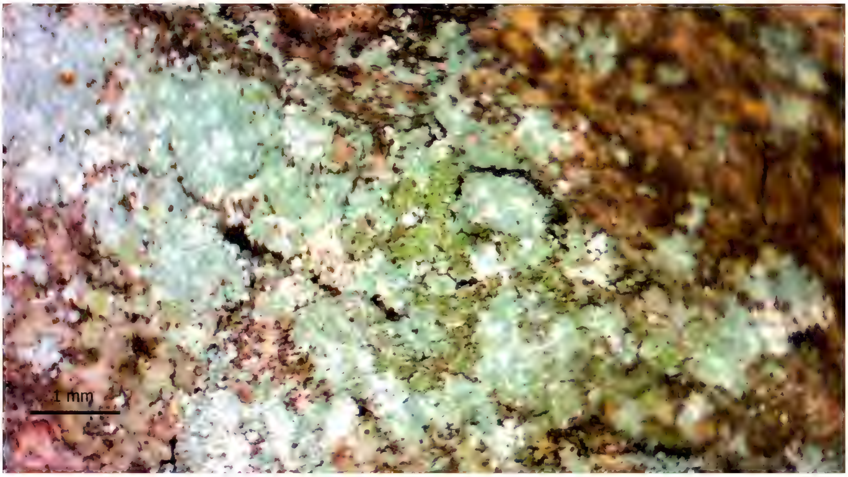

FIG. 2. *Lepraria ecorticata* (TARI, Kazemi 8784).

HABITAT: *Lepraria ecorticata* grows on shaded places on acidic rocks, on siliceous and calcareous rocks and walls, and (rarely) on the bark of *Populus*, *Tilia*, and *Fraxinus* (Laundon 2003, Tsurykau & al. 2016). The specimen reported here was found on *Parrotia persica* in montane Hyrcanian forest.

GEOGRAPHICAL DISTRIBUTION: Asia (China), Europe, North America, South America (Kukwa 2006).

Lepraria jackii Tønsberg, Sommerfeltia 14: 200. 1992. FIG. 3

TYPE: Norway, Nord-Trøndelag, Grong, W of Abrahammyra, 80–100 m, 16.ix.1981, on *Picea abies*, T. Tønsberg 6176 (BG [n.v.], holotype).

Thallus greenish-grey to whitish-green, leprose, without stratified and alternate margin, at first forming separated granules that later accumulate to continuous masses, without marginal zone, without lobes; hyphae unilateral, hyaline; without prothallus; hypothallus absent; without rhizohyphae; granules spherical, well developed, separate, and forming multiplex units; medulla present, white, sparse to continuous; soredia abundant, without projecting hyphae, ecorticate, small, dispersed or forming a thick, continuous layer, sometimes in larger clusters (consoredia).

CHEMISTRY: Thallus K+ yellow, C–, KC–, P+ yellow.

TLC: Atranorin (fatty acids are also reported but were not clearly visible on our plates).

Specimen examined: **IRAN**, **Golestan province**: **Gorgan**, Naharkhoran road, around environmental station, 36.7911°N 54.4665°E, 387 m, Kazemi 9019 (TARI).

Comments: The Iranian material does not show significant differences from the detailed descriptions of *L. jackii* presented by Kukwa (2006), Czarnota & Kukwa (2001), Matwiejuk (2017), Saag & al. (2007), and Tsurykau & al. (2016).

Lepraria jackii can be confused with *L. caesioalba* as both have atranorin and similar reactions with K and P, but *L. caesioalba* can be distinguished morphologically by its obscure sublobes while *L. jackii* completely lacks lobes.

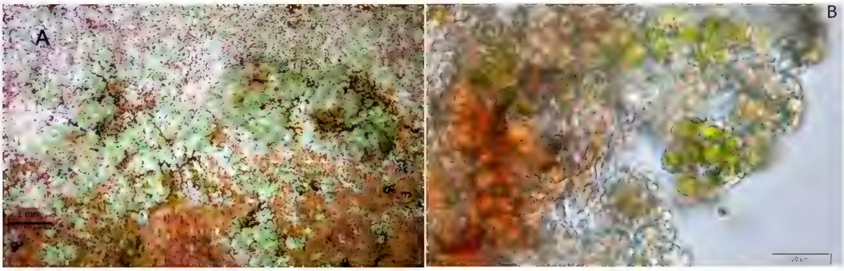

Fig. 3. *Lepraria jackii* (TARI, Kazemi 9019).
a. Thallus; b. Photobiont cells.

Habitat: *Lepraria jackii* grows on conifers (*Picea abies*) and rarely on sheltered rocks or humus, on mosses and soil, and sometimes on other lichens (Tønsberg 1992, Saag & al. 2007, Lendemer 2013). The specimen reported here was found on *Zelkova carpinifolia* bark in a Hyrcanian forest.

Geographical distribution: Asia (Armenia) (Gasparyan & Sipman 2016), Europe, North America, Australia (Saag 2009).

Lepraria leuckertiana (Zedda) L. Saag, Lichenologist 41: 41. 2009. Fig. 4

Type: Italy: Sardinia: Prov. Sassari: Illorai, Monte Artu, 1494647E, 4472420N (Gauss-Boaga), 840 m, on bark and mosses on old *Quercus pubescens* Willd. trees in a mixed wood of *Q. pubescens* and *Q. ilex* L., in open conditions, 9.4.1997, L. Zedda 1800(2) (B [n.v.], holotype; herb Zedda and SS [n.v.], isotypes).

Thallus greenish-white to greenish-grey, leprose, thick and powdery to granular; without margin, often sublobate, hyphae condensed, pale; prothallus absent; medulla white, exposed in some parts, forming a thick layer; soredia abundant, granular, fine to coarse, gathered into consoredia. Soralia ecorticate, with short projecting hyphae, hyphae to 4-5 µm diam., pale and branched, unorganized.

Chemistry: Thallus K–, C–, Pd–, KC–.

TLC: Usnic acid, zeorin; isousnic acid is also reported but was not clearly visible on our plates.

> SPECIMEN EXAMINED: **IRAN**, **GOLESTAN PROVINCE**: **Gorgan**, Naharkhoran road, Delbar mountain, 36.7467°N 54.5001°E, 1092 m, 17.11.2017, Kazemi 8784 (TARI).

COMMENTS: Our specimen agrees fully with the detailed descriptions of *L. leuckertiana* presented by Saag & al. 2009, Zedda 2000.

Morphologically *L. leuckertiana* resembles *L. vouauxii* but differs in spot test and chemistry; chemically *L. leuckertiana* resembles *L. ecorticata* and differs by the strongly agglutinating, not well separated soredia.

HABITAT: *Lepraria leuckertiana* grows on old trees (especially on *Quercus*), on palm and olive trees, and on sandy soil and roots (Zedda 2000). The specimen reported here was found on *Quercus castaneifolia* bark in a montane Hyrcanian forest.

GEOGRAPHICAL DISTRIBUTION: Asia (Gasparyan & Sipman 2016, Paukov & al. 2017), Africa, Europe, South America (Saag 2009).

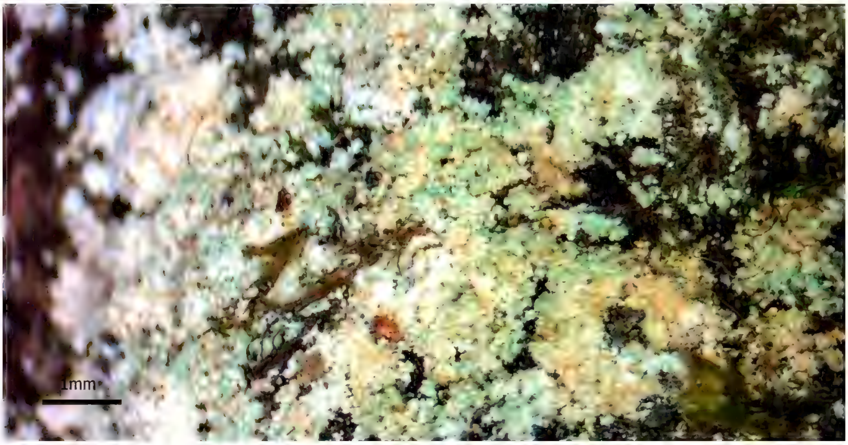

FIG. 4. *Lepraria leuckertiana* (TARI, Kazemi 8784).

Key to the *Lepraria* species in Iran

1 Thallus surface granular; soredia coarse, >100 µm in diam.,
sometimes elongate and isidium-like 2
Thallus surface powdery; soredia mostly <80 µm in diam. 5

2 On mineral soil; fumarprotocetraric acid present;
granules indistinct, partly elongate and isidioid . . . . ***L. isidiata***
On rock or moss over rock; fumarprotocetraric acid absent;
granules distinct, not isidioid 3

3 Stictic acid present; thallus K+ yellow to orange .... *L. lobificans*
Stictic acid absent; thallus K– or + pale yellow to pale brown 4

4 Thallus K+ brown, Pd + red, with protocetraric acid .... *L. nivalis*
Thallus K+ yellow, Pd+ yellow, with psoromic acid and atranorin *L. caesioalba*

5 Alectorialic and protocetraric acids present (staining paper brown in herbarium); medulla thick and distinct .... *L. eburnea*
Alectorialic acid absent (not staining paper in herbarium) 6

6 Divaricatic acid with nordivaricatic acid and zeorin present, soredia C+ red .... *L. crassissima*
Divaricatic acid absent 7

7 Stictic acid present; soredia K+ yellow to orange .... *L. finkii*
Stictic acid absent 8

8 Pannaric acid (or pannaric acid derivatives) as primary substance 9
Pannaric acid and its derivatives absent or present only in trace to minor amounts; other major compound(s) present 12

9 4-Oxypannaric acid 2-methylester as primary substance .... *L. diffusa*
4-Oxypannaric acid 2-methylester absent or present in only trace to minor amounts; other major dibenzofurans present 10

10 Thallus with distinct lobes; pannaric acid as primary substance, other minor dibenzofurans also present .... *L. membranacea*
Thallus indistinctly or not lobed; pannaric acid absent or present only in trace to minor amounts, pannaric acid-6-methylester present 11

11 Thallus with distinct lobes with raised marginal rim; lecanoric acid and pannaric acid-6-methylester present; C+ red .... *L. impossibilis*
Thallus with indistinct lobes without marginal rim; pannaric acid 6–methylester alone present; C– .... *L. vouauxii*

12 Porphyrilic acid present .... *L. alpina*
Porphyrilic acid absent; thallus powdery 13

13 Usnic acid and zeorin present 14
Usnic acid absent, zeorin absent or present 15

14 Medulla thick and cottony .... *L. leuckertiana*
Medulla thin or absent .... *L. ecorticata*

15 Soredia small, without projecting hyphae .... *L. jackii*
Soredia large, with projecting hyphae .... *L. rigidula*

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